Welcome to

PCB 5423

ADVANCED ECOLOGY: Populations and Communities

Fall 2012

Instructor: Joel Trexler

office MSB 361; 305-348-1966

Meeting times: MWF 10:00-11:15 Classroom: MSB 362; HLS 216

Class webpage: http://bioserv.fiu.edu/~trexlerj/Advanced_Ecology.htm

Textbooks: Gotelli, N. J. 2008. A Primer of Ecology, 4th Edition. Sinauer

Ricklefs, R. E., and G. L. Miller. 2000. Ecology, 4th ed. W. H. Freeman

Moran, P. J. 2011. Community Ecology, 2nd Ed. Blackwell (purchase is optional)

Class webpage:
http://bioserv.fiu.edu/~trexlerj/Class_webpage.htm

Note that links on this are webpage

are password-protected

Username: Advanced_Ecology

Password: Fall_2012

Read the Fine Print!

- **Purpose**: Provide a common foundation for our incoming graduate students interested in ecology. We will seek to increase your familiarity with the theory and practice of modern population and community ecology. Three textbooks will be used to provide background material for lectures and discussions of current papers from the primary literature. Students will also employ computer software to familiarize themselves with the basic models of population and community ecology.

- **Student responsibilities**: You are expected to do the assigned reading, work problem sets, take oral exams, and participate in class throughout the term.

Read the Fine Print!
Grades

- You will complete six problem sets during the semester (combined 60% of the total points). Grades based on your preparation for and participation in class, including discussions, will account for 10% of the total. Finally, 30% of your grade will be derived from your performance on two oral exams designed to simulate comprehensive exams. (Yes, you have no in-class tests).

- Final grades will be determined by your performance compared to other students in your class and compared to the performance of past groups of students. It is possible for all students to make 'A' in this class and, generally, most students make A or B. Generally, graduate students perform well in this class because it is important for their research. In the Biology Department, MS students earning a grade of A in both semesters of Advanced Ecology may be able to skip the comprehensive exam. I have given grades below a C in past semesters, but not often and only to students who didn't do the work throughout the semester. Feel free to ask questions about grading at any point in the semester.

Learning Objectives

1. **Factual Material -** *A mastery of factual material covered in lectures available by downloading from the class webpage.* These lectures are supplemented by assigned reading material. In addition to topical material, you must develop some appreciation of the historical development of ideas in population and community ecology. This history will be available in the lecture and reading material, and in technical papers you are assigned to read. This knowledge will be tested in oral exams given at the class mid-term and final exams, as well as on problem sets and during class discussions..

2. **Problem solving: analytical skills, literature research, and synthesis-** *Demonstration of quantitative, literature research, and synthetic skills in answers you provide to problem sets assigned throughout the semester*. Problems will range from simple quantitative problems solved using computer programs to open-ended questions requiring use of library research tools and analysis of published papers. This knowledge will be tested by problem set administered throughout the semester

Note: Rubrics for grading will be provided in advance of each assignment and the oral exams.

Accessing POPULUS

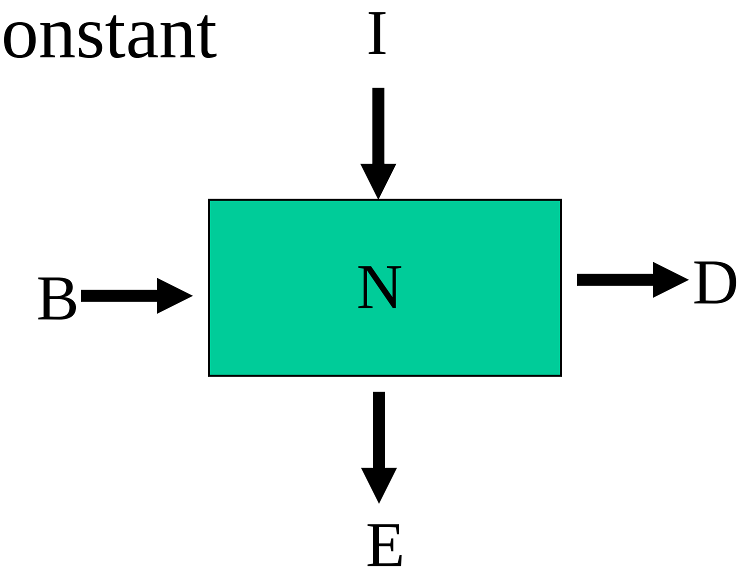
We will use a free computer program to illustrate many of the topics of this class:

http://www.cbs.umn.edu/populus/

You will also be called upon to create some simple spreadsheet models using EXCEL or comparable programs of your choice.

Density-Independent Population Growth

- What is a population?
  - A group of individuals of the same species living in a place
  - $N_{t+1} = N_t + (B - D) + (I - E)$
  - Assume B, D, I, and E are constant
  - For closed pop: I = E = 0
    - $\Delta N = B - D$



Density-Independent Population Growth

- Two types of population models
  - Discrete generation
  - Continuous growth
    - $dn/dt = B - D$
    - B, D indicate number B & D over very small time intervals
    - Useful to consider as a rate where:
      - $B = bN$ [b is births/(ind·time)]
      - $D = dN$ [d is deaths/(ind·time)]

Density-Independent Population Growth

Notes:

- Assumes births and deaths depend on current N;
- Model may include a time lag to account for disconnection of regulation and density in time;
- Density-dependent model with b & d a function of N is next topic

Density-Independent Population Growth

Our model simplifies to:

$$dN/dt = (b-d)N$$

Where $b-d = r$ instantaneous rate of increase

- r is *per capita* rate of pop change (per head)
- $r > 0$ pop grows
- $r = 0$ pop remains constant
- $r < 0$ pop declines
- Pop growth (dN/dt) $\propto N$ $\therefore$ bigger N faster rate of growth

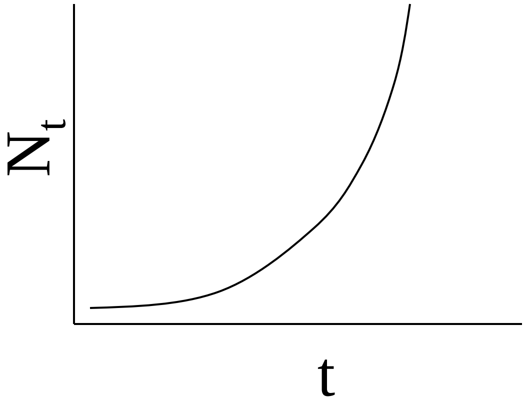
Density-Independent Population Growth

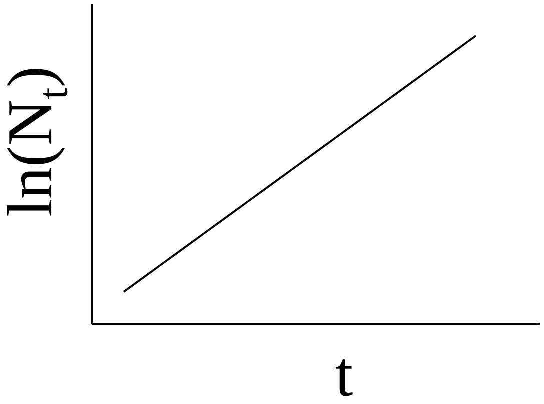
$$dN/dt = (b-d)N$$

$$dN/dt = (r)N$$

Integrate: $N_t = N_o e^{rt}$ [recall $e \cong 2.717$]

Take logs: $\ln N_t = \ln N_o + rt$





Density-Independent Population Growth

A useful parameter is doubling time:

$$2N_o = N_{tdouble} = N_o e^{r \cdot tdouble}$$

$$2 = e^{r \cdot tdouble}$$

$$\ln(2) = r \cdot tdouble$$

$$\ln(2)/r = tdouble$$

$\therefore$ r ↑ yields tdouble ↓

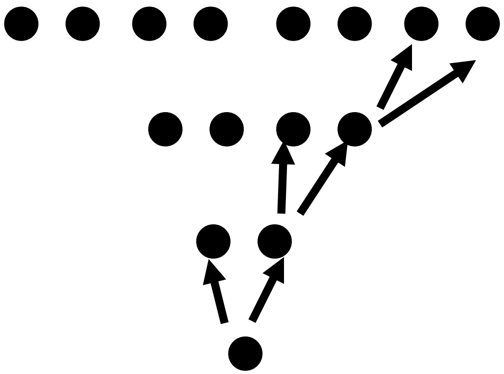
(see Table 1.1 Gotelli for examples)

Density-Independent Population Growth

Assumptions of this simple model:

1. No immigration or emigration;
2. Constant b and d;
3. No genetic structure (all inds identical);
4. No age or size structure (i.e., sexless, pathenogenetic pop with ind reproducing @ birth… closest to bacteria);
5. No time lags in growth.

Density-Independent Population Growth



Gen	N
0	1
1	2
2	4
3	8

Consider discrete generation case, uses difference equations

$$N_{t+1} = \lambda N_t$$

where λ = finite rate of increase

$$\lambda = N_{t+1}/N_t$$

$$N_2 = \lambda N_1 = \lambda(\lambda N_o) = \lambda^2 N_o$$

General form: $N_t = \lambda^t N_o$

For example: $N_3 = N_o 2^3 = 1 \cdot 8 = 8$

Density-Independent Population Growth

Note, relate λ to r as follows:

$$N_t = N_o e^{rt}$$

$$N_t/N_o = e^{rt}$$

$$\ln(N_t/N_o) = rt$$

$\ln(\lambda^t) = rt$ or simply $\ln\lambda = r$

$\lambda^t = e^{rt}$ or simply $\lambda = e^{rt} \cong 2.717^r$ @ $t = 1$

Also note:

$$r > 0 \Leftrightarrow \lambda > 1$$

$$r = 0 \Leftrightarrow \lambda = 1$$

$$r < 0 \Leftrightarrow 0 < \lambda < 1$$

Density-Independent Population Growth

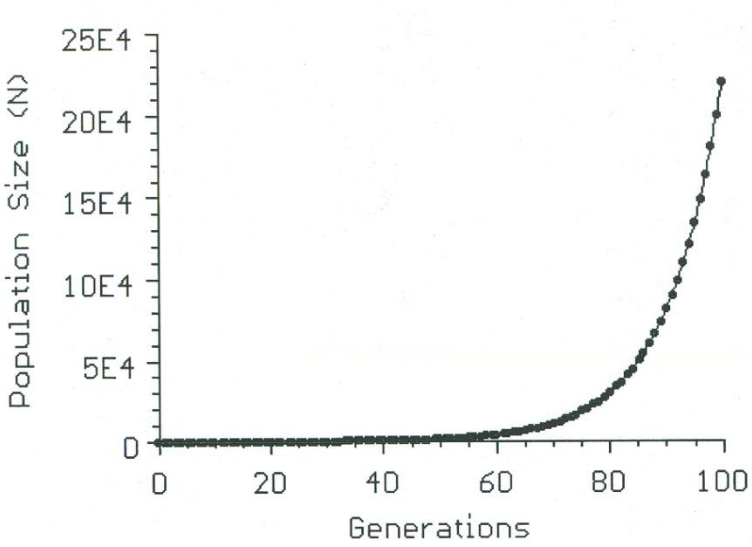
Also note:

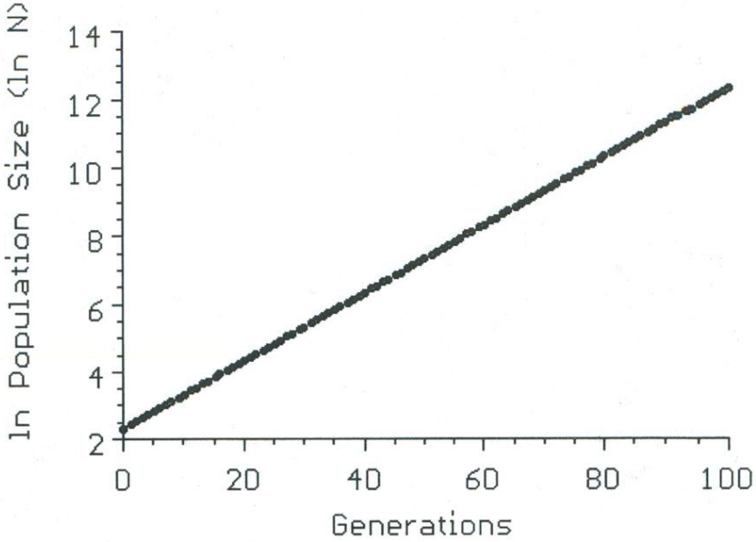
λ changes with different time increments;

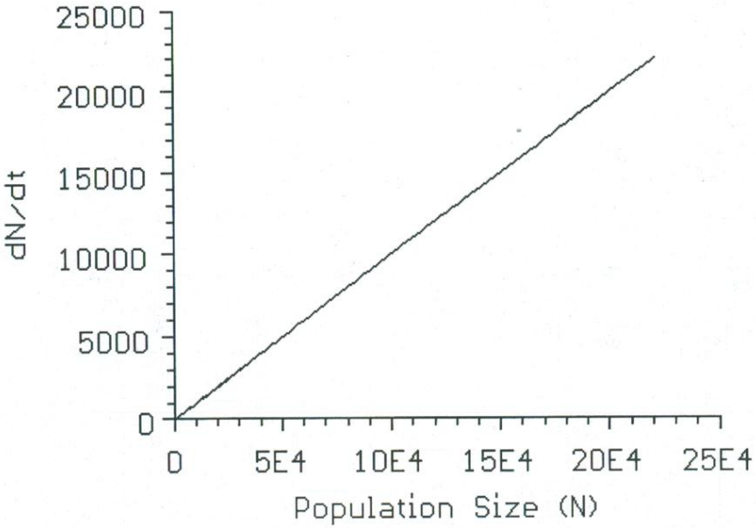
To change time step for λ,

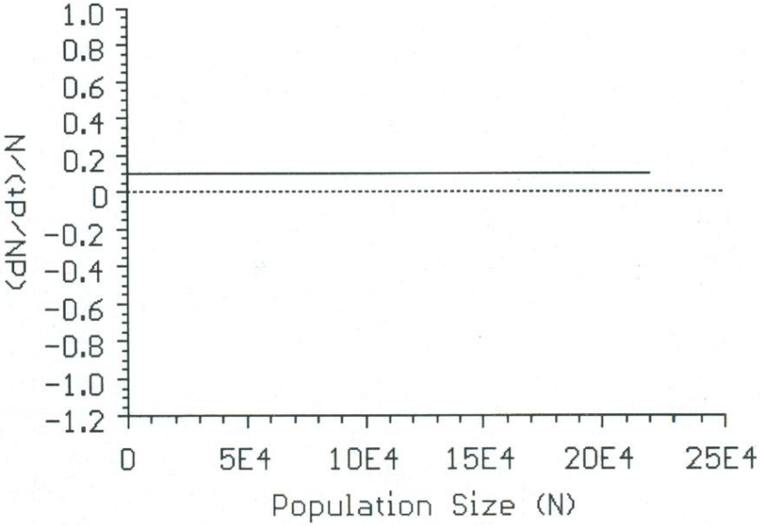
convert to r (#ind/ind·time) then divide or multiply r to proper time step and convert back to λ (think about units!)

Continuous $N_0 = 10$ $r = 0.1$

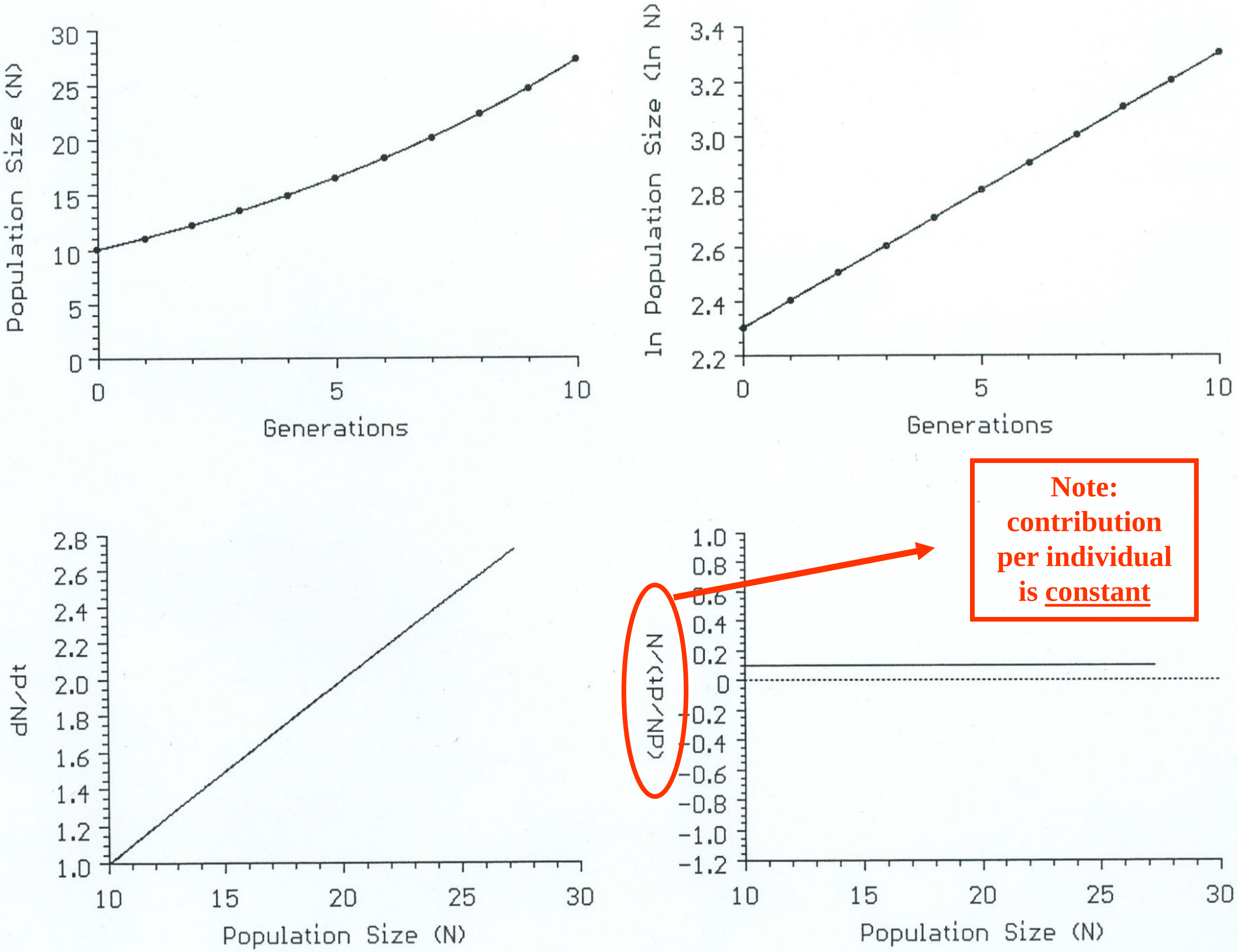




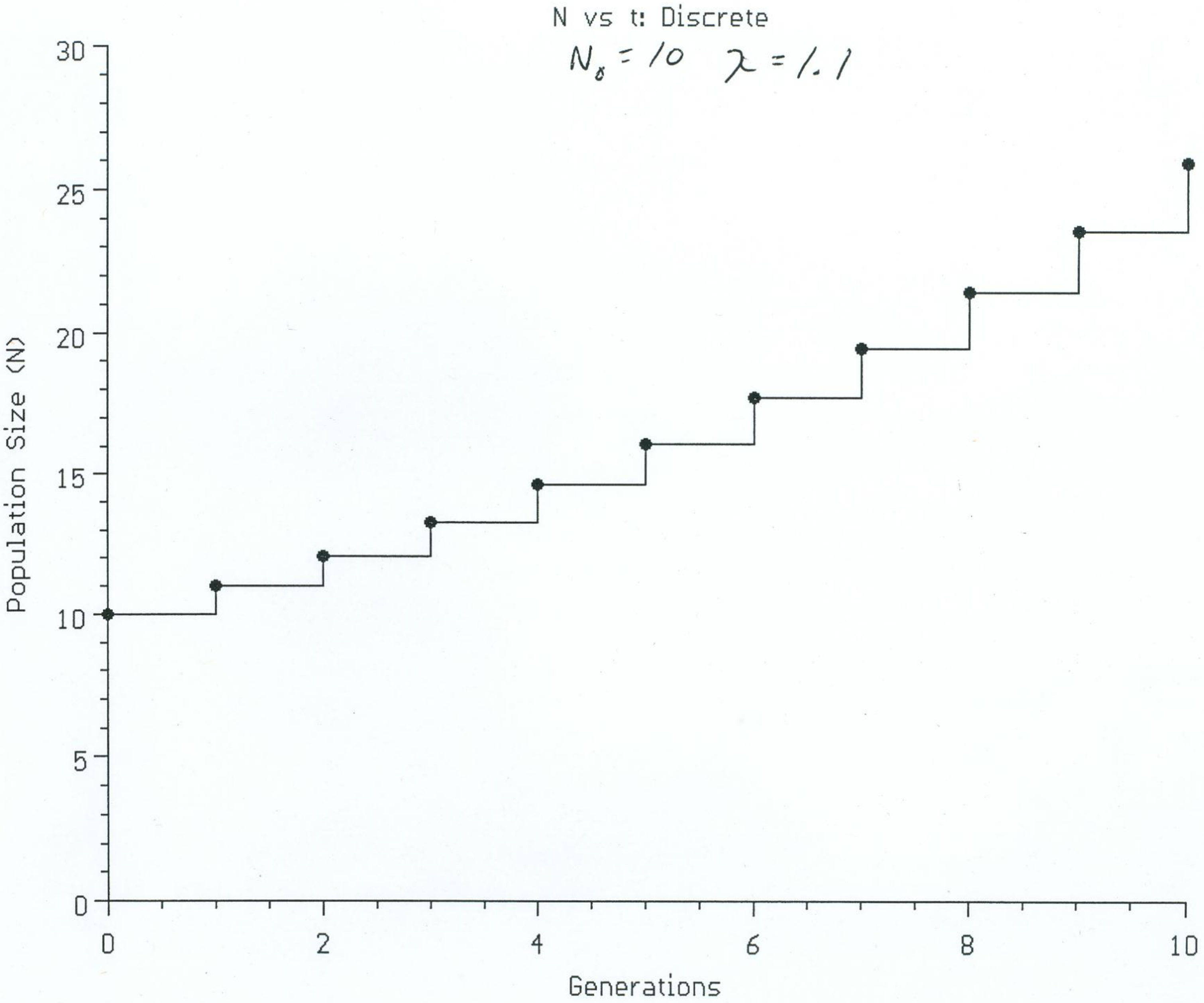




Continuous $N_0 = 10$ $r = 0.1$



Note: contribution per individual is constant



$N_0 = 10 \quad \lambda = 1.1$

Density-Independent Population Growth

Two kinds of models: Deterministic & Stochastic

Environmental stochasticity

- Imagine r varies → $\bar{r}$ and σ_r^2
- Note1: that $\sigma^2_{N_t}$ increases with t because uncertainty increases the further we project into the future [also, chance deviations early in growth process propagate and exaggerate through time… a principle called chaos].
- Note2: $\sigma_r^2 > 2\cdot\bar{r}$ and

extinction is inevitable ☹

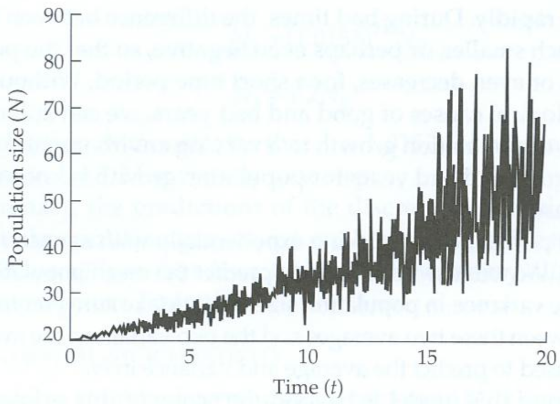


Figure 1.3 Exponential growth with environmental stochasticity. In this model, the instantaneous rate of increase fluctuates randomly through time. Here $N_0 = 20$; $r = 0.05$; $\sigma_r^2 = 0.0001$.

Density-Independent Population Growth

Demographic stochasticity

Consider for a given individual:

Pr(birth) = b/(b+d)

Pr(death) = d/(b+d)

Note $\bar{r}$ may be positive but chance sequence of b or d still leads to a decline in N, especially at small N.

- The significance of this is ∝ N
- Variance in N increases with time

Density-Independent Population Growth

Demographic stochasticity (continued)

Note: b & d inversely proportional

$$\Pr(\text{extinction}) = (d/b)^{No}$$

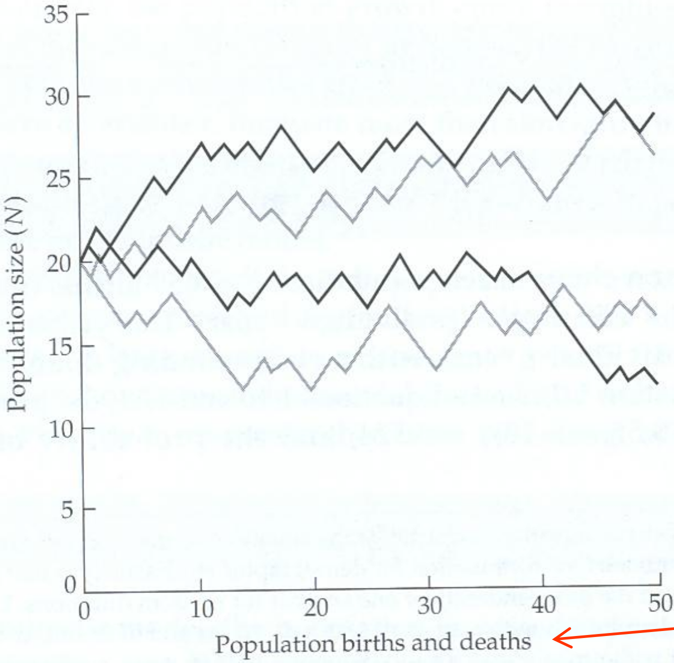
With b and d per capita births and deaths.

The greater d and b, the greater chance of extinction, even with $\bar{r} = 0$ (bigger changes per time step are possible)

- Two key stochastic model types:
  - – Demographic (most important for small N)
  - – Environmental

Density-Independent Population Growth

Demographic stochasticity



birth &death events

Figure 1.4 Computer simulation of population growth with demographic stochasticity. Each population track starts with an *N* of 20 individuals. $b = 0.55$ births / (individual • year) and $d = 0.50$ deaths / (individual • year). Although the starting conditions are identical, two of the populations actually dipped below the initial population size by the end of the simulation. Note that the *x* axis is not absolute time, but the number of sequential population events (births and deaths).